cloud formed in the southeast and passed directly over the station. At 3 p. m. a terrific peal of thunder, without visible lightning, occurred. This was followed by rain. In twelve minutes 0.51 inch of rain fell. Then a second peal of thunder occurred, not as loud as the first. The rain ceased, and in a few moments the sun was shining in noonday splendor. On the 20th a black cloud formed in the north and a similar cloud formed in the northwest. These clouds met on the hills west of the station and 450 feet above it (measured by barometer). When they met, hail commenced to fall, at 3 p. m., and continued about half an hour. The hail lay inches deep on the ground and remained into the night. Some people gathered hail by the pailfull and froze ice cream with it. This hail and that of the 11th damaged growing crops and thrashed growing peas. During a residence of thirteen years I have not observed a similar month of thunderstorms, and have no desire to see it repeated.

RECENT EARTHQUAKES.

On June 20, 1897, at 8:30:29 a. m., at Port au Prince, an earthquake shock. At first a horizontal stroke coming from the east, and two seconds afterward a stroke from the northeast, lasting three seconds. After an interval of two seconds a nearly vertical shock occurred, followed by another of the same character but less intense. At 8:31:30 a last feeble, horizontal shock came from the north. Small movements of the earth were indicated by the Bertelli tromometer until 9 a. m. The preceding data are taken from the curves traced by the Cecchi seismograph and are communicated by Dr. P. J. Scherer, director of the observatory at Port au Prince, Hayti, in connection with his meteorological report for this month. (The observatory is located at N. 18° 34′, W. 71° 21′; altitude, 37.20 meters.)

July 25, Castle Pinckney, slight. [This may be the same as the following.—Ed.]

July 26, San Francisco, 5:40 p. m. (8:40 eastern time) a sharp, short, and heavy earthquake, preceded by a low rumbling sound. No damage is reported. At the Weather Bureau office, in the Mills Building, Mr. A. G. McAdie registered the time as 5:40:35; the trembling lasted about two seconds; the motion was apparently in a vertical direction.

KITES AT THE CHICAGO CONFERENCE, AUGUST, 1893.

In previous pages of the MONTHLY WEATHER REVIEW the Editor has collected a number of items illustrating the early use of the kite for meteorological investigations. The recent development of this subject can, probably, only be written after searching through many popular and technical journals. In order to assist our readers, and to complete our collection of data on this subject, the Editor will occasionally review the items published in some of these journals.

The International Conference on Aerial Navigation, held in Chicago, August 1–4, 1893, under the auspices of the Columbian Exposition, seems to have originated in a suggestion by Prof. A. F. Zahm, of Notre Dame University, in Terre Haute, Ind., and forms an important epoch in the history of the use of the kite in America. The proceedings of this conference were published in a series of papers appended to the American Engineer and Railroad Journal, but which also appeared separately, as Vol. I of Aeronautics, a proposed periodical which, however, stopped with No. 12 of that volume, which was published in September, 1894. They were rearranged and printed in a volume of proceedings, in 1895. The conference, and the wide publication of its proceedings, owes its success largely to the devotion of the famous Engineer, Mr. Octave Chanute, of Chicago, who was chosen chairman, and Prof. A. F. Zahm, who was chosen secretary of the committee, to organize and carry out the project.

The attendance at each session comprised about 100 persons who seemed to take great interest in the proceedings, and discussions brought out several investigators who had been studying the subject or trying interesting experiments without making it publicly known.

The following items referring to kites are taken from Vol. I of Aeronautics; the rest of that magazine is mostly occupied with discussions relative to flight by birds and aeroplanes, the pressure of the wind on inclined surfaces, and other correlated matter.

On page 43 will be found the memoir of Prof. Langley on "The Internal Work of the Wind," which had been read by title in April, 1893, but now in full at this meeting of the International Conference, where it excited great attention and discussion. Among the items brought out in the discussion of this first publication of this memoir were the interesting communications from Professor Marvin, page 87, and Professor Zahm, page 99.

The gustiness of the wind has been an object of study for the past two centuries, but it was reserved for the professors of the Weather Bureau to show that, inasmuch as we do not measure gusts with an apparatus that has no inertia, we must, therefore, attempt to compute the gusts and their effects by the use of several anemometers simultaneously that differ among themselves only in their inertia. Professor Marvin, therefore, had in 1888 devised and constructed several forms of light paper hemispherical or conical cups, such that the moment of inertia of the revolving mass was but a small fraction of that of the ordinary metallic anemometer. He also introduced the aluminum cups whose moment of inertia is quite small. With such apparatus he determined the effect of gustiness on the ordinary anemometer records, both at the City of Washington and on the summit of Mount Washington, and deduced the formula and tables, published by the Weather Bureau in 1889 and recommended for ascertaining the true velocity from that indicated by the Robinson anemometer. These ingenious paper cups and the results of Marvin's work, being known to the late Mr. G. E. Curtis of the Weather Bureau, had by him been brought to the notice of Professor Langley, who, through the Chief of the Weather Bureau, obtained Professor Marvin's apparatus for use in his observations, as detailed on page 45 of Langley's memoir. To the present Editor it seems that, in order to measure the gusts which affect kites and do such great destruction in tornadoes, we must employ either the suction anemometer, as was explained in his lectures of 1882, and his Treatise of 1887, or the paper apparatus constructed by Professor Marvin, and described by him in the American Meteorological Journal, April, 1889, Vol. V, page 556. In general, the less the inertia of the measuring apparatus is called forth so much the shorter and more violent are the recorded gusts and variations in the wind—at least near the surface of the ground where measurements must be taken; but the infinite irregularity of these gusts and eddies can best be perceived by watching the flotation of motes in the sunbeam in still air, or thistle down and snowflakes in ordinary winds.

On page 71 Mr. Carl Myers, of Frankfort, N. Y., states that—

> I constructed some kites with a flexible backbone and which when released would advance relatively against the wind, that is, they would not drift back as fast as the wind blew. An account of some of these kite experiments will be found in the Scientific American Supplement (No. 835) for January 2, 1892.

On page 72 Prof. J. B. Johnson, of Washington University, St. Louis, states his belief that the gusts recorded by Professor Langley are not typical, and explains how he has "tested the gustiness of the ordinary atmospheric movements by observing the column of smoke from a tall chimney."

On page 82 Mr. William A. Eddy, of Bayonne, N. J., in a letter dated January 11, 1894, describes the "soaring aeroplane kite." He states that he—

> Had heard of the buoyancy of the malay kite, but was unable to get measurements showing its construction, when in 1890 he began the

difficult task of reinventing it. He first saw the original type of this kite in the Javanese village at the Columbian Exposition in August, 1893, and then found that, after three years of experiment, he had evolved a kite like the original, but with a higher cross stick bent backward and downward like a bird's wing that has completed the upward stroke in flying. This last improvement was made at the suggestion of Mr. Charles L. Flanders, of New York, who had made and flown a malay kite at Cape Town, South Africa. The kite at the Javanese village resembled a model which I had discarded because of its insufficient steepness in ascending. The malay calm kite will rise and remain up in a dead calm layer of air only when the person holding it walks at the rate of 2 or 3 miles per hour, but it will reach and penetrate the lower cumulus cloud strata in a 3-mile wind, if flown tandem. Usually a calm precedes the moment when the wind is about to suddenly reverse. * * * With the sudden cessation of all wind, the malay kite releases its tension upon the string holding it, which then hangs straight down beneath the kite. * * * If pulled in rapidly in a calm the kite not only reaches the zenith in a position nearly horizontal to the earth, but progresses on beyond the zenith, owing to its momentum, and then again makes a long descent. * * * The convex under surface of this kite presents an important condition of aerial flight.

Page 99, Prof. A. F. Zahm, of Notre Dame, Terre Haute, Ind., describes the studies made by himself and his brother, Prof. J. A. Zahm, of the same university, on the behavior of the wind. He constructed a universal anemoscope, whose vane was so pivoted on horizontal and vertical axes as to be free to point in all directions. The azimuth and angular altitude of the vane was recorded continuously, together with the horizontal velocity of the wind, but finding that the Robinson cups used by the Weather Bureau possessed too much inertia, he tried the aluminum screw-anemometer constructed by Richard Bros., with results similar to those of Marvin, Fergusson, and Langley. He says:

While at the Johns Hopkins University, in the spring of 1893, I employed an exploring line to indicate to the eye the waves of a changeable air current. It consists of a strong, fine thread, having attached to its extremity a small rubber balloon, inflated just sufficiently to fairly float. When paid out in a breeze, the balloon rises and falls with every billow, like a cork on the water, and the line itself is bent into waves, sometimes of monstrous size, thus enabling one to form a conception of the actual billows of the atmosphere.

I do not mean to assert that the direction of the line accurately portrays the direction of the wind at all its parts, for the pull of the balloon tends to straighten the line, but I am sure that it does not give an exaggerated indication, because the pressure of the wind must always be against the concave parts of the line; hence the wind's course must be even more wavy than the line itself. If the main exploring line had along its length a number of short branch lines, each tipped with a small balloon, the branches would point out the direction of flow in their immediate locality.

After some preliminary tests from the top of the physical laboratory of the Johns Hopkins University, during the Easter vacation of 1893, I ascended the Washington Monument at Baltimore, where I paid out the exploring line at a height of 200 feet. The wind was blowing toward the southeast at the speed of 25 to 35 miles per hour, and the sky, which had remained clear till 3 o'clock, was rapidly darkening, with indications of approaching rain. The balloon when let forth immediately fell to a depth of 30 or 40 feet, being caught in the eddy of the monument, then presently encountering the unbiased current, sailed in it toward the southeast, approximately level with the spool end of the thread. After the balloon had drawn out 100 feet of thread, I checked it to observe the behavior of this much of the exploring line. The balloon rose and fell with the tossing of the wind, but did not flutter like a flag, as it would do if formed of irregular outline. Neither did the thread flutter, nor do I believe there is ever a tendency in a line to greatly flutter in a current as does a flag or sail. Presently I paid out 300 feet of the exploring line, whereupon the waves in the thread became quite remarkable. The thread, then, as a rule, was never approximately straight. Sometimes it was blown into the form of a helix of enormous pitch, at other times into the form of a wavy figure lying nearly in a single vertical plane, and again the entire exploring line would veer through an angle of 40° to 60°, either vertically or horizontally. The balloon would, of course, seldom remain quiet for more than a few seconds at a time, but tossed about on the great billows like a ship in a storm. Quite usually the billows could be seen running along the line from the spool to the balloon, and, as a rule, several different billows occupied the string at one time.

The observations just delineated, however curious they may be, afford no adequate conception of the behavior of the air currents over an open plain nor at a great height above the earth, because the Washington Monument of Baltimore stands but 100 feet above the surrounding buildings, which undoubtedly send disturbances to a greater height than 200 feet. To supplement these explorations, therefore, I determined to have them repeated from the top of the Washington Monument at Washington and the Eifel Tower at Paris.

Toward the latter part of the Easter vacation I again let forth the exploring line from the top of the Washington Monument, at Washington, at a height of 500 feet. A stiff breeze was blowing from the northwest and as the locality is quite free from obstructions everything seemed favorable for an exploration of the free air. But, unfortunately, I had not taken into consideration the enormous magnitude of the monument and of the consequent eddies surrounding it. Accordingly, when the balloon was let forth from one of the windows it was involved in a large and violent eddy from which it could in no manner be extricated. Rising vertically upward from the window to a height of some 25 feet it encountered the direct current and sailed toward the southeast with great rapidity to a distance of 30 or 40 yards, then suddenly turned to the right, being caught in a mighty whirlpool which sucked it downward through an enormous spiral path to a depth of 100 feet, and again threw it upward to the top of the monument, thus returning it quite near to my hand. After witnessing these evolutions for 10 minutes I was obliged, by the lateness of the hour, to return to the elevator without having observed the behavior of the exploring line in a direct current. I saw, however, what precautions would be advisable to insure the success of a second attempt.

The above rather long quotation gives us a very beautiful picture of the behavior of the vortices in the rear of an obstacle, but still fails to tell us to how great a distance from the obstacle these influences are felt. In his "Preparatory Studies" the Editor has quoted an observation of as many as seventeen vertical, cylindrical vortices, arranged in a row for several miles to the leeward of a tall chimney, and in his "Cloud Observations at Sea," he has shown how a series of clouds, representing the summits of horizontal rolls or waves, stretches for 50 miles to the leeward of Green Mountain on the Island of Ascension. In attempting to send up small hydrogen balloons for the determination of the wind velocity at sea, the Editor found that when liberated from the deck of a sailing vessel the balloons spent a long time entangled in the eddies in the rear of the sails and after finally escaping from these pursued an irregular path that demonstrated the far-reaching influence of these eddies.

On pages 106–107 Mr. J. Bretonnière describes the peculiarities of the wind, as observed by him at Constantine, Algeria. This city occupies a deep depression, and a line of high points passing through the city forms a barrier against the prevailing winds and produces a series of eddies, by means of which he was able to explain the flight of birds; great ascending and descending currents, as well as deflections to the right and left and rotating eddies, both stationary and traveling, filled the atmosphere to a height of at least 1,500 feet above the ground. Among the numerous detailed examples of local currents described by Bretonnière, we quote the following:

I saw one day a long and narrow object, resembling a rumpled newspaper, rise from the point of which I have just spoken, and above which some soaring bird had just been ascending. This object rose by fits and starts rapidly, in a direct vertical line in which it was suspended, with its length vertical. When it arrived at the height of about 300 meters, it was caught by a horizontal current and carried to another point, where it fell swiftly. I think that the newspaper occupied during its ascension the axis of a whirlwind. * * * In a few words, the greater inequalities of the ground transform the lower layers of the prevailing winds into ascending currents, and these, sometimes by their mutual reactions or by the action of the generating winds upon them, give rise to new currents more markedly ascending, or to whirling winds, or to whirlwinds.

The application of his numerous observations to the flight of birds are very full and clear, but do not belong to our present subject.

On page 112 it appears from a review of a work entitled Aeronautics, or an abridgment of aeronautical specifications filed at the British Patent Office from 1815 to 1891, that the aeroplane and its mechanical properties were first clearly presented by William S. Henderson, in 1842.

On pages 117–120 Mr. E. C. Huffaker, of eastern Tennessee, gives a number of minute observations on the wind and currents around the ridges and hills of that region and their connection with soaring flight.

Page 126, Mr. W. S. Bates, of Chicago, describes the kite used by Capt. Sir Georges Nares to carry a line ashore in case of shipwreck. The figures are reproduced from Captain Nares' work on seamanship; and the Nares kite seems to be similar in principle to the malay kite. It soars horizontally in the air, as if the wind were obliquely upward instead of horizontal; it consists essentially of a midrib and two triangular pieces of cloth, which slope from the midrib backward, but are kept apart by a cross stick at the rear.

On page 138 is the famous paper by Lawrence Hargrave, of Sidney, N. S. W., and the introductory remarks by A. F. Zahm, secretary of the conference. This seems to have been the first opportunity that Americans had to see and appreciate the cellular kite of Hargrave. These published proceedings and a subsequent paper by Hargrave in 1895 indicated the superiority of the Hargrave kite over the malay and started Professor Marvin in that line of research which is now producing such interesting results for meteorology. The complete details of Hargrave's labors during the past two decades are published in the Proceedings of the Royal Society of New South Wales. A condensed account is likewise given in Mr. Chanute's work, Progress on Flying Machines, and in the columns of the American Engineer and Railroad Journal for May, September, October, 1893.

Hargrave's experiments on the form of the kite were originally prompted by the desire to ascertain the best disposition of supporting surfaces in his flying machines. He says:

The novelty, if any, consists in the combination of two well-known facts: 1. That the necessary surface for supporting heavy weights may be composed of parallel strips superposed with an interval between them (described by Wenham in 1866 and adopted by Stringfellow in 1868). 2. That two planes separated by an interval in the direction of motion are more stable than when conjoined (patented by Danjard in 1871). The form which the complete kite assumes is like two pieces of honeycomb fastened on the ends of a stick, the stick being parallel to the axes of the cells. The cells may be of any section or number. The rectangular cells are easiest to make, and if the stick or strut between the two cells is placed centrally it is immaterial which side of the kite is up. Practically the top or bottom is determined by imperfections in the construction. The rectangular form of cell is, also, collapsible when one diagonal tie is disconnected. These kites have a fine angle of incidence, so that they differ from the kites of our youth, which we remember floating at an angle of about 45°, in which position the lift and drift are about equal. The fine angle makes the lift largely exceed the drift and brings the kite so that the upper part of the string is nearly vertical. Theoretically, if the kite is perfect in construction and the wind steady, the string could be attached infinitely near the center of the stick and the kite would then fly very near the zenith. It is obvious that any number of kites may be strung together on the same line, and that there is no limit to the weight that may be buoyed up in a breeze. * * * If a string of kites gets into contrary currents of air the kites and suspended weight may be disconnected from the earth and will remain supported, drifting in a resultant direction, determined by the force of each current and the number of kites exposed to it. * * * A kite whose horizontal surfaces are curved with the convex sides up pulls about twice as hard on the string as one of equal weight and area with plane surfaces.

On pages 152-153 Mr. William A. Eddy, of Bayonne, N. J., gives an account of his experiments with hexagon kites and tailless kites. He says:

In 1890 I began experiments to determine the relation between the width and length of the ordinary kite. My object was to evolve the best form of kite to be used in raising self-recording meteorological instruments to a great height, because many important problems in meteorology would be affected by investigations of the upper air currents.

I first found that a narrow kite would not remain well in the wind. It made a swift movement downward to the right or left, while a short broad kite, if properly weighted with tail, would fly well. It was evident that greater lifting power and kite surface could be obtained by filling in the points of the well-known six-pointed star kite, thus making a hexagon or six-sided kite. The lifting power and steepness with which the string reached up to the kite were remarkable. In certain winds this kite might have approached the zenith had not the weight of the tail held it back. This lifting power suggested the possibility of attaining great altitudes with a large kite. But a very large kite must be flown with a heavy rope throughout, while if other kites were attached to a main line then heavy rope would be required near the earth's surface only. In putting the lighter line aloft there is an obvious saving of weight as well as of power to withstand the strain of additional kites. * * * The limit of altitude attainable by means of tandem kites is yet to be determined. The 1891 experiment convinces me that if several miles of twine were extended upward into space the steep slant of the line could be maintained by increasing the size and number of the kites. With 10 miles of line and 50 kites from 2 feet to 8 feet diameter, an altitude of 4 miles ought to be reached, unless the rarefied air should fail to exert sufficient pressure. * * * When the tandem strings of kites are flying I have often noticed astonishing variations in the directions of air currents. Once when a string of kites was very high I observed that the upper kites described a sharp angle of direction as related to the lower, and when the kites were drawn in this sharp angle disappeared as the earth was approached. In case an altitude of 6 miles were reached, this variation in current might imperil the main line of kites by carrying all the upper ones away from the lower in an opposite direction. The variation in air currents may be a serious obstacle at times, but my experience during several hundred kite ascensions, both with and without a thermometer, is that a reversed current is exceptional if the kites are high in the air. I have observed only two reverse movements during two years at Bayonne, and these were at the surface. * * *

In time I think the malay kite will attain an altitude equaling that of the highest balloon ascensions at a relatively small cost, and that it will remain with its recording instruments several days in the *cirrus* clouds at a height of 9 miles. This may call for many decades of experiment. A balloon floats and drifts away and endangers life, but a kite, or a line of them, will remain nearly stationary and enable self-recording instruments to give us invaluable data at a great height above a local point, and during hours, and possibly days. The law of the upper air movements can be mastered only by an incessant waste of kites, owing to breakage and loss. At present great heights can be reached only during daylight; and if time is lost in adjusting kite tails to various wind velocities, then night may come on and the experiment be further delayed by the necessity of attaching lanterns to the strings below the kites. With a strong tandem line of large kites perpendicular cords can be run up to an upper kite and the instruments raised and lowered unless the altitude is too great.

At twilight during July and August I have many times noticed that while no wind was moving near the ground, yet the lower clouds were moving rapidly. With a long string laid along the ground to the kite I have, by walking slowly backward, raised the malay kite to an upper current during a calm at the surface. The vertical thickness of a mass of sluggish air may be often penetrated, yet when the calm air extends to a considerable height it may be difficult to get above it. A rapid walk of two miles would doubtless bring success, particularly at twilight in summer when the night winds set in. The vertical thickness of calm air may be sounded upward to a great distance by rapid motion at the surface. At night in summer the upper winds are steady, while a dead calm prevails at the surface of the earth; and when the day breeze is inadequate, then these evenly flowing night winds are sufficient. During several years I have not observed a continuous twenty-four hours when an upper current could not be reached, as evinced by the motion of tree branches. The kites rarely fly in precisely the same direction, owing to differences in the angle of inclination. The upper currents are revealed by a difference of direction, as compared with the direction manifested by the same kite at the ground. In the rare case that any two kites happen to fly exactly alike, they can still be maintained aloft by placing one kite a few feet farther away than the other, upward along the main line.

On the nights of June 2 and 3, 1893, a kite penetrated a cloud coming in from the sea and remained invisible some time. In August, 1892, the kite penetrated a shower cloud for a moment—it faded away and then came forth—but as the kite was of paper it was necessary to haul it down. The kite of June 2 and 3 was about 4 feet across, tailless, of paper, and rose to a height of about 1,200 feet. The clouds had probably begun to descend, but the surface was not foggy until toward midnight, the kite having been sent up about sundown. Water drops collected on the string near the kite while aloft, but at the ground the string was perfectly dry. This kite while in the air was soaked by mist which caused it to slowly descend.

The success of this tailless kite depends upon its surface being adjusted with extreme exactness. In case too much surface appears on one side the kite will fly sideways and work its way out of the line of the wind. This can be partly remedied by attaching small weights at one side of the kite; but if the surfaces adjoining the central spine are too much out of balance, even the adjustment of weights will not make the kite fly.

A further series of experiments with perforated malay kites will be carried out during 1894. So far I have experimented by cutting the outline of a small kite out of the center of a large one. This lessened the wind pressure during high winds and caused increased persistence of movement. Extreme accuracy is called for, however, if a large opening in the kite is made, because a mistake of an inch will cause a side movement that will carry the kite downward. The late Mr. C. W. Hastings made an important suggestion regarding the management of kites in high winds—the kite to be proportionately and slightly weighted with sheet lead at its center of gravity, thus giving it inertia in high winds and resulting in stability. As before mentioned in this paper, I tried this method in the summer of 1892, when Mr. Hastings visited me at Bayonne, and found it successful. It remains to be elaborated in 1894. * * * In 1892 I read that some Chinamen flew kites at the base of Washington Monument, Washington, D. C., with the object, I suppose, of using the shaft to measure the altitude of their kites. Since the monument is 555 feet high, it would, of course admirably serve the purpose of a long unit of measurement. But the part of their pastime that interested me most was that they cut holes in their kites to make the movement steady. It seemed to me that if perforation produces steadiness, then the same principle might apply to flying-machine planes. I experimented with paper planes and found that a narrow-pointed plane, if given a convex under surface, might fall in equilibrium if launched with an impetus. But if a long narrow piece of paper were cut out of the center, as you might cut the bottom out of a boat, and along nearly its entire length, then the same plane, if weighted, will glide easily and swiftly through the air in the direction in which the first impulse is given. As about one-fifth of the plane is cut out from the center, it follows that there is a gain in lightness for flying purposes. A small model of this plane was mailed by me to Mr. Octave Chanute from New York City on June 5, 1893.

On pages 153–156 is the memoir presented to the International Conference by J. Woodbridge Davis, in which he relates the details of some experiments with kites which were apparently made in 1892–93 at various points on the coast of Rhode Island. His kites generally—

Consisted of a frame-work of three sticks of equal dimensions, pivoted at the center, free to turn on the pivot. They could, therefore, be folded for convenience of transportation. The general outline of the kite was that of a six-pointed star. The actual weight of a 7-foot kite, with cover and rigging, designed for a 40-mile wind is 6.25 pounds. This kite will safely bear a wind pressure of 250 pounds; the sticks are made of American ash. In order to steer the kite the three bridle lines attached to the three arms on the left side of the kite are brought to a single point where they are tied to a ring in such a manner as to be easily changed in length; the three bridle lines on the right-hand side are in the same way tied to another ring. To these two rings are separately fastened the two flying lines. These flying lines are manila cords, tested to bear 350 pounds each, and are paid off from two light wooden reels screwed to a platform pegged to the ground. By properly paying out these lines the kite is made to veer to the right or to the left through a deflection of 67.5° either way from the direction of the wind. As the tail always streamed out to leeward, therefore the kite was twisted around the vertical in proportion as the deflection increased. The next improvement was the attachment of a third or top line, by which the inclination of the plane of the kite to the horizon could be changed. When the top line was drawn in, the kite was made to mount to a point almost overhead. By using the top line and one flying line, the other being clamped, the kite was made to describe curves in the air; it was, for instance, lowered to a point 40° or 50° away from the leeward direction where an attendant pinned a message to the tail; the kite was then made to rise and travel to another place where it delivered the message. Again, it was made to drag a buoy and rope line through a strong cross tide, about five-eighths of a mile to a pier on Riker's Island. The top line steadied the kite on the same principle as the tail, besides supporting it until it could be made self-supporting; the flying lines steadied the kite laterally like guy lines, besides steering it, so that it could be accurately and steadily drawn in or let out through a space in the rigging of the vessel scarcely wider than itself. With one line the kite was unsteady in its movements; with two lines there was not the slightest tendency to lateral oscillation.

Finally, on pages 166–167 is the interesting paper of Prof. Mark W. Harrington, at that time Chief of the Weather Bureau. The following extracts are of historical interest, as bearing upon the use of kites:

The exploration of the upper air is the immediate requirement for the satisfactory advance of meteorology. There is abundant reason to think that many of the changes which go under the name of weather have their origin at some distance above the earth; and of what occurs in the cloud layer or layers, our knowledge is insignificant or theoretical. * * * The method of kites has been studied especially by Mr. William A. Eddy, of Bayonne, N. J., and the data which I give I owe entirely to his kindness. He uses tailless kites, places them in tandem, and recommends that they be flown in groups of three. By such means he has already attained heights of 4,000 to 5,000 feet, and confidently expects to attain 14,000 feet without serious difficulty. On my request that he estimate the cost of carrying meteorological instruments to this height, he gave me the following estimate, on the basis that the line would average an angle of 45° with the horizon, and would have to be about 23,000 feet in length. * * *

Mr. Eddy adds "that in lighter winds, perhaps 50 kites would be required, the above estimate applying for winds of about 10 miles per hour. All the kites are tailless, and fly at an angle of about 80° from the horizontal for the first 300 feet of line out. In case the pull becomes too great for the breaking strain the lower and larger tandem kites can be hauled in. The breaking strain of the cordage must be known and the pull at the earth's surface constantly measured to prevent the entire line from breaking away. This is a rough estimate, but is founded upon careful experiments during two years. The top kites and twine should be laid out the night or the day before, and the line should be extended along the ground for several thousand feet. Soon after daybreak the top kites should be started up, the top one lifting up the next, and so on. The kites will right themselves regardless of the position in which they are when lifted by the higher kites. Instruments should be suspended between two groups of three kites each.

Three tailless kites will fly when any one of the three will not, in very mild surface winds. For safety it would be well to have the kites in groups of threes."

Mr. Eddy is not ready to give a limit to which kites can be flown, but is not without hope that they can be made to reach the cirrus clouds. In winds of high velocity the kites must be perforated to relieve them from too strong air pressure. The tailless kites easily right themselves when reversed, and a tandem series of kites tends to prevent the jerking which might put the instruments out of order. * * *

The preceding (three) methods, while they would give highly interesting and instructive results, would be somewhat imperfect as a means of obtaining all the information needed by meteorologists. Much better for this purpose would be systematic work by a meteorologist who would make the ascension himself. Evidence points to the conclusion that the cloud layer, and perhaps the upper cloud surface, is a region of especial activity in meteorological phenomena, but the facts by which such a conclusion could be verified are of such a character that they would probably escape any automatic registry. Their record requires the presence of a trained meteorologist. These observations should be systematic, as the sporadic ones are of relatively little value. A meteorologist should ascend twice a day to a considerable height, and should keep this up through all kinds of weather, and through the season. The elevation need not be great, probably the first 20,000 feet include the layer of air in which the meteorological phenomena which we call weather are active. At least the stratum of this thickness is far more important to us than all the rest of the depth of the atmosphere.

The cost of such a campaign would be considerable, but would vary with the material used, the care in using it, the position of the station, etc. I think a year's campaign of this sort could be gone through for an expense of $20,000.

In conclusion, it appears that a year's campaign could be made in the free air at the following estimated cost:

To 3,000 feet (perhaps) with small balloons	$3,000
To 14,000 feet with kites	10,000
To 20,000 feet, 52 pilot balloons. } To 50,000 feet, 12 pilot balloons. }	3,000
To 20,000 feet with aeronaut	20,000

The results to be obtained would be cheap at any of these prices; but the fourth method seems to be incomparably the best as well as the most certain. A year's campaign of this sort would add very greatly—more than any other possible way in the same time—to the knowledge of meteorology, and hence to the forecasting of the weather. There is no other way, I believe, in which this sum of money could be expended to the greater advantage of meteorology.

After the reading of the above paper it was, upon the motion of Mr. D. Torrey, unanimously resolved:

That it is the sense of this meeting that the experiments proposed by Mr. Harrington are likely to prove of public value in forecasting the weather, and that Congress should, in our judgment, make the necessary appropriation to have the experiments made as recommended by Mr. Harrington.

In concluding this review of the state of our knowledge in 1893, the Editor would call attention to the fact that the malay kite and the free balloon were then looked upon as the means for occasionally obtaining isolated items of information from the upper regions; the world had not then awakened to the possibility of the work inaugurated by Professor Moore in July, 1895, which looks to the compilation of a daily map of simultaneous observations high above the earth's surface and over a large portion of the United States, for study in connection with the map of surface conditions. Observations of the air at a single station can have but little value compared with the international balloon work of Europe or the extended national kite work of the Weather Bureau.

In his recent address at Toronto, before the British Association for the Advancement of Science, Professor Moore said:

For twenty-seven years the forecasters of the Weather Bureau have studied the inception, development, and progression of these different classes of atmospheric disturbances. From a knowledge personally gained by many years service as an official forecaster, I do not hesitate to express the opinion that we have long since reached the highest degree of accuracy in the making of forecasts possible to be attained with surface readings. It is patent that we are extremely ignorant of the mechanics of the storm; of the operations of those vast yet subtle forces in free air which give inception to the disturbance and which supply the energy necessary to continue the same. Long having realized this, I determined at once, on coming to the control of the United States Weather Bureau, to systematically attack the problem of upper-air exploration, with the hope ultimately of being able to construct a daily synoptic weather chart from simultaneous readings taken in free air at an altitude of not less than one mile above the earth. It appeared to me that all previous plans for investigating the upper air, by means of free and uncontrollable balloons, by observers in balloons, or by isolated kite stations or mountain observatories, were of little value in getting the information absolutely necessary to the improvement of our methods of forecasting. Simultaneous observations, at a uniform high level, from many cooperating kite stations, was the fundamental feature of the plan that I inaugurated for the prosecution of this important investigation.

Professor Marvin was assigned to the difficult task of devising appliances and making instruments, and I am pleased to say that we have improved on kite flying to such an extent that apparatus is now easily sent up to a height of one mile in only a moderate wind. We have made an automatic instrument that, while weighing less than two pounds, will record temperature, pressure, humidity, and wind velocity. By January next we expect to have not less than twenty stations placed between the Rocky Mountains and the Atlantic Ocean taking daily readings at an elevation of one mile or more.

We shall then construct a chart from the high-level readings obtained at these twenty stations and study the same in connection with the surface chart made at the same moment. As we shall thus be able to map out not only, as now, the horizontal gradients for the lower surface conditions, but in addition the simultaneous gradients for the upper level, and what is of still more importance, shall be able to deduce from these, for any section of the atmosphere, the simultaneous vertical gradients of temperature, humidity, pressure, and wind velocity, we may confidently hope to better understand the development of storms and cold waves, and eventually improve the forecasts of their future course, extent, and rate of movement. * * * It will be a fascinating study to note the progress of cold waves at the upper and lower levels, and to determine whether the changes in temperature do not first begin above. * * * I am anxious to know the difference in temperature between the surface and the upper stratum in the four quadrants of the cyclone, and also of the anti-cyclone, especially when the storm or cold-wave conditions are intense. * * * The vertical distribution of temperature in the several quadrants may give a clue to the future direction of movement of the disturbance.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation; the altitudes of the instruments, the total depth of snowfall, and the mean wet-bulb temperatures are now given.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (....).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, total depth of snowfall, and the respective departures from normal values. Reports from Newfoundland and Bermuda are included in this table for convenience of tabulation.

Table IV gives detailed observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, meteorologist to the Government Survey.

Table V gives, for 26 stations, the mean hourly temperatures deduced from thermographs of the pattern described and figured in the Report of the Chief of the Weather Bureau, 1891–'92, p. 29.

Table VI gives, for 26 stations, the mean hourly pressures as automatically registered by Richard barographs, except for Washington, D. C., where Foreman's barograph is in use. Both instruments are described in the Report of the Chief of the Weather Bureau, 1891–'92, pp. 26 and 30.

Table VII gives, for about 130 stations, the arithmetical means of the hourly movements of the wind ending with the respective hours, as registered automatically by the Robinson anemometer, in conjunction with an electrical recording mechanism, described and illustrated in the Report of the Chief of the Weather Bureau, 1891–'92, p. 19.

Table VIII gives, for all stations that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions based on these two observations only and without considering the velocity of the wind. The total movement for the whole month, as read from the dial of the Robinson anemometer, is given for each station in Table I. By adding the four components for the stations comprised in any geographical division one may obtain the average resultant direction for that division.

Table IX gives the total number of stations in each State from which meteorological reports of any kind have been received, and the number of such stations reporting thunderstorms (T) and auroras (A) on each day of the current month.

Table X gives, for 56 stations, the percentages of hourly sunshine as derived from the automatic records made by two essentially different types of instruments, designated, respectively, the thermometric recorder and the photographic recorder. The kind of instrument used at each station is indicated in the table by the letter T or P in the column following the name of the station.

Table XI gives a record of rains whose intensity at some period of the storm's continuance equaled or exceeded the following rates:

Duration, minutes..	5	10	15	20	25	30	35	40	45	50	60	80	100	120
Rates pr. hr. (ins.)..	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.86	0.84	0.75	0.60	0.54	0.50

In the northern part of the United States, especially in the colder months of the year, rains of the intensities shown in the above table seldom occur. In all cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest rainfall of any single storm has been given, also the greatest hourly fall during that storm.